TITLE: **APPLICATION OF FOAM FOR STEAM DRIVE CONFORMANCE CONTROL AT COLD LAKE - PHASE I**

Part of Energy, Mines and Resources Cost-Shared Energy Conversion Program and Part of the Program of the Federal Panel on Energy Research and Development (PERD).

Final Report

by

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EXECUTIVE SUMMARY

The subject of this project is to test the ability of a steam surfactant (Chevron Chaser SD1020) to generate a foam in situ that will improve steam conformance and hence bitumen recovery. The objective in Phase I was to determine if a foam could be generated under Cold Lake Clearwater reservoir conditions. From July 29 to August 29, 1991 a foaming surfactant was added to the steam injected in three wells at Esso's Leming pilot K Pad.

1. Significant rapid wellhead injection pressure increases were observed for two wells and a more gradual increase for the third. These pressure increases are usually indicative of near wellbore blocking of steam by foam.
2. The pressure increases were sustained when the chemical injection period was reduced from 24 to 8 hours/day and the concentration was reduced from 1% to 0.3% of the liquid volume fraction.
3. There was no significant oil production response possibly due to the short duration of the test.
4. Measured total dissolved solids of the produced water (a possible indicator of steam diversion) was inconclusive and was not supported by production response.
5. A base oil production decline was established.

The injection wellhead pressure response is sufficiently encouraging that it is recommended to proceed with Phase II, a 300 day test in the same three wells (K5, K14 and K16) at

K Pad, using Chevron Chaser SD1020 foaming surfactant and Nitrogen. From this longer test it will be possible to judge the potential of the surfactant to improve oil production.

RESUME D'EXECUTION

Le sujet de ce projet consiste à tester la capacité d'un surfactant de vapeur (Chevron Chaser SD1020) à générer in situ une mousse permettant d'améliorer la conformité de la vapeur et, par suite, la récupération du bitume. L'objectif de la Phase I était de déterminer si une mousse peut être généréo dans les conditions du réservoir Cold Lake Clearwater. Du 29 juillet au 29 août 1991, un surfactant moussant fut ajouté à la vapeur injectée dans trois puits de la Base K pilote de Esso à Leming.

1. Des augmentations rapides et importantes de la pression d'injection dans la tête de puits furent observées pour deux puits, ainsi qu'une augmentation plus progressive pour le troisième. Ces augmentations de pression indiquent généralement un quasi-blocage de la vapeur par la mousse dans l'orifice dans l'orifice du puits.
2. Les augmentations de pression subsistèrent lorsque la durée d'injection du produit chimque fut réduite de 24 à 8 heures/jour et lorsque la concentration fut réduite de 1% à 0.3% du volume de la fraction liquide.
3. Probablement en raison de la courte durée du test, il n'y eut pas de modification notable de la production de pétrole.
4. La mesure du total de solides dissous dans l'eau produite (un indicateur possible de diversion de vapeur) ne fut pas concluante, et ne fut pas confirmée par les modifications au niveau de la production.

5. On a mis en évidence un déclin de la production de pétrole de base.

Le comportement de la pression d'injection dans la tête de puits est suffisamment encourageant pour que l'on recommande d'entamer la Phase II, un test de 300 jours dans les trois mêmes puits (K5, K14, et K16) de la Base K, en utilisant le surfactant moussant Chevron Chaser SD1020 et de l'azote. A partir de ce test d'une durée plus importante, il sera possible de juger le potential du surfactant en ce qui concerne l'amélioration de la production de pétrole.

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1. INTRODUCTION

Cold Lake is one of the major oil sands deposits in Alberta. Esso Resources Canada Ltd. has conducted experimental pilot operations in the area since 1964 and began commercial production in 1985. The current bitumen production rate is around 14000 m3/d.

The zone of primary interest is the Clearwater formation. It is a thick (50 m) unconsolidated sandstone buried at a depth of 460 m (Figure 1). The bitumen saturation averages 10% by weight or about 70% of the pore volume.

Cyclic Steam Stimulation (CSS) is in wide use to recover the bitumen. In this process steam is injected and alternately bitumen produced from a well. It is estimated that up to 20% of the original bitumen in place will be recovered using CSS. Additional bitumen can be recovered by using a follow up process such as steam drive where there is continuous or intermittent steam injection in selected wells and continuous production from the rest of the wells. This could further be enhanced by injection of a surfactant with the steam to generate a foam in situ, to improve steam conformance and provide additional bitumen recovery. This is the subject of this project.

In this phase the objective was to determine if a foam could be generated in the formation before committing to additional expenditures to conduct a longer term test that

is necessary to determine if recovery can be improved. The test was conducted at Esso's Leming pilot K Pad.

1.1 K Pad History

The original 12 wells of K Pad were drilled in 1979 along two rows with six wells per row. In 1982, five equally spaced infill wells were drilled mid-way between the two original rows giving a total of 17 current wells with a well spacing of .85 Ha/well (Figure 2). Interwell distance is about 67 m by 125 m. Prior to 1987 the original wells underwent 8-10 cycles of steam stimulation and the infill row underwent five cycles of steam stimulation. In 1987 continuous steam injection was initiated in wells K5 and K9. Two additional steam injectors, K14 and K16, were added in 1988. These four steam injectors have been in use, with some interruptions, from 1988 to the present. The producers have not been significantly steam stimulated since 1987 except for K6 which was stimulated mid 1990. Four wells have received small 'warm up' (500-1300 m3) steam volumes.

2. FOAM APPLICATION

From July 29 to August 29 1991 a foaming agent (Chevron Chaser SD1020) was added to the steam injected in wells K5, K14 and K16 (Figure 2). K9 was used as a control well.

2.1 Surface Facilities

An equipment flow diagram is shown in Figure 3. The chemical injection system consisted of a 48 m3 (300 bbl) chemical storage tank, a chemical recirculating pump, and four chemical injection pumps with associated metering. The surfactant was delivered by Chevron Chemical Company from California by truck to the storage tank as a 10% active solution. A total of four truck loads were received (82117 litres) during the test. A pump truck was used to inject additional water in the wells during the early part of the test.

2.2 Injection Data

2.2.1 K5

The steam injection rate at K5 had been fairly constant at around 80 m3/d with a wellhead pressure of 900 kPa in late July 1991 prior to the test (Figure 4). Chemical injection began on July 29 at 2:02 PM. Extra water was also injected into the well at this time as it was thought that the steam would initially not have a sufficient liquid volume to allow formation of an effective foam. Injection data from the start of chemical injection is shown in Table 1 and Figures 5a and 5b. Figure 5a shows the first four days of injection.

Figure 5b shows all of the test period. The chemical injection rate was initially 5.05 l/m (litres/minute) and the water rate was 25 l/m. This amount of chemical represents about a 1.0% active concentration in the liquid injected assuming a 60% downhole steam quality. Chemical and water injection rates were increased in an effort to generate a foam and a subsequent steam injection WHP (wellhead pressure) increase. These efforts were successful and the WHP increased to 1350 kPa in 2.75 days, a 60% increase. Thereafter the chemical and water injection rates were reduced but the increased WHP was still maintained. Water injection was stopped after 3.75 days on August 2. Chemical injection was reduced to .6 l/m (0.3% active concentration) with an injection period of 24 hours per day and after 12 days to .6 l/m with an injection period of only 8 hours per day. The increased steam WHP still maintained at around 1300 kPa. The pressure would start to decrease as soon as chemical injection was stopped and would continually decline until chemical injection was resumed in 16 hours. This injection strategy was continued until the end of injection on August 29. Following this the pressure fell quite rapidly even though at roughly the same time the steam rate was increased. A total of 37300 gross litres (3767 Kg. active) of surfactant was injected at this well. This is a prorated (.906 factor) amount based on the surfactant delivered.

2.2.2 K14

The steam injection rate at K14 was fairly constant at around 100 m3/d with a wellhead pressure of just under 1200 kPa in late July 1991 prior to the test (Figure 6). Chemical injection began on August 7 10:00 AM at 4.7 l/m. Additional water injection of 20 l/m was also used at this well. The water was started a half hour earlier than the chemical. Injection data from the start of chemical injection is shown in Table 2 and Figures 7a and 7b. Figure 7a shows the first two days of injection. Figure 7b shows all of the test period. The initial amount of chemical represents about a 1.0% active concentration in the liquid injected, the same concentration used in K5. The WHP in this well responded much quicker than K5. It started to increase almost immediately and continued to increase quite steeply over the next 8 hours. Thereafter the increase was more gradual reaching a peak of 1950 kPa, a 56% increase in 24 hours. Because of the better response the chemical rate was reduced to 3.1 l/m after half a day and the water injection eliminated entirely. The chemical was then further reduced in steps to a final rate of 0.8 l/m (0.3% active concentration) for 8 hours a day. The WHP did decline from the peak to an average of about 1700 kPa but this was still 36% higher than the starting pressure. As with K5 the WHP would start to decline as soon as chemical was shut off over

night and then would increase when chemical was started 16 hours later. Chemical injection was stopped on August 29. The WHP fell rapidly back to the prior level of 1250 kPa. A total of 20900 gross litres (2111 Kg. active) of surfactant was injected at this well. This is a prorated (.906 factor) amount based on the surfactant delivered.

2.2.3 K16

The steam injection rate at K16 had been fairly constant at around 95 m3/d with a wellhead pressure of 1600 kPa in July 1991 but did drop to 1350 kPa just prior to the test (Figure 8). Chemical injection began on August 2 9:30 AM at 4.3 l/m. Additional water injection of 18 l/m was used at this well. The water was started 45 minutes earlier than the chemical. Injection data from the start of chemical injection is shown in Table 3 and Figures 9a and 9b. Figure 9a shows the first two days of injection. Figure 9b shows all of the test period. The initial amount of chemical represents about a 1.0% active concentration in the liquid injected, the same concentration used in K5 and K14. The WHP in this well responded similar to K14 only slightly faster. The peak increase was 2250 kPa a 61% increase in 24 hours. The chemical was reduced to 2.7 l/m and the water injection eliminated entirely after only 7 hours. The chemical was then further reduced in steps to a final rate of 0.8 l/m (0.3% active concentration) for 8 hours a day the same as

K14. At this well, the average WHP had an overall increasing trend (Figure 9b) possibly indicating that a foam bank was continuing to grow. As with K5 and K14 the WHP would start to decline as soon as chemical was shut off over night and then would increase when chemical was started 16 hours later. Chemical injection was stopped on August 29. The WHP then fell rapidly back to a level of 1750 kPa which was higher then the prior WHP of 1600 kPa (Figure 8). It was not until 2.5 months later that the 1600 kPa level was consistently seen again. A total of 23900 gross litres (2414 Kg. active) of surfactant was injected at this well. This is a prorated (.906 factor) amount based on the surfactant delivered.

2.2.4 K9

Well K9 was used as a control well for the test. No surfactant was injected at this well. The steam rate and WHP remained reasonably constant during August as shown in Figure 10.

3. PRODUCTION DATA

3.1 Test Response

Due to the short nature of this test an oil production rate increase was not anticipated. However there were production

changes on two wells. Well K7 had an increased wellhead temperature, casing pressure, and oil rate (Figure 11) during August. This trend continued in effect after the end of the test so there is much doubt as to whether it was a result of the foam test or was part of a longer term previous trend. Well K15 also showed an increased wellhead temperature and casing pressure, but a decreased oil cut and hence oil rate (Figure 12) during August. Again it is not clear whether these effects were a result of the foam test. No other significant production changes were seen at any of the other wells.

3.2 Base Decline

The current K Pad oil production decline is shown in Figure 13. The test did not produce any significant change on K Pad as a whole due to its short nature. However, there is now established a base decline (due to the relatively constant steam injection rate) from which to judge future increases in oil rate in a subsequent Phase of the test.

4. TOTAL DISSOLVED SOLIDS DATA

Total dissolved solids (TDS) were measured in produced water wellhead samples collected two weeks prior to the start of the test and for three months after the test. Increased levels of TDS might be an indication that less fresh water

is being produced and therefore steam is being diverted. The data is shown in Table 4. On average there was an 1100 mg/l variance in samples taken prior to the test. Therefore only changes greater than this are considered meaningful. The most significant changes were seen in the October 29 data for wells K2, K3, K17, and V17. Well K3 also showed an increase in all succeeding months after the test. Wells K4, K7 and K8 showed increases on October 29 as well but not to as great an extent. There were other changes in specific wells but no other trends. Whether the October 29 data was a deviation or was indicating steam diversion is uncertain. There were no supporting production changes. A longer term test may provide more conclusive data.

5. DISCUSSION OF RESULTS

Overall the results are encouraging. Significant WHP increases were observed at all injectors within a short time period. When the chemical rates were decreased and cyclic injection used the pressure increases were maintained. The pressure build up at K5 was not as fast as at K14 and K16. Reasons for this could be different K5 wellbore conditions, lower K5 steam rates hence velocities, or possibly lower K5 steam quality. Well K5 is an older well and has received 50% more steam. Also it has a 50% longer perforation interval and double the perforation density. Because the pressure build up on K14 and K16 was so rapid, there is a concern

that the pressure increases could be due to a skin effect or a near wellbore foam only. This would be investigated further during the next phase. TDS data was not conclusive. Ultimately, it is the oil production response that will show if an effective foam did form.

6. FUTURE PLANS

The WHP pressure is encouraging but a longer term test is necessary to establish if there will be a significant production response which is needed to make the process economic. It is recommended to proceed with Phase II, a 300 day test in the same three injectors at K pad and using the same chemical Chevron Chaser SD1020. It is also recommended that Nitrogen be injected with the steam and chemical during Phase II. The purpose of the Nitrogen will be to stabilize the foam as it advances further from the wellbore where steam may be condensing. Incorporating learnings from Phase I should allow an efficient start up and less chemical usage especially for K5. There is a base oil production decline established from which to judge any subsequent oil rate increases.

TABLES

Table 1

K5 FOAM TEST - PHASE I - INJECTION DATA

DATE	TIME	STEAM m3/d	WHP kPa	CHEMICAL l/m	CONCENTRATION %	WATER l/m
7/29/91	13:35	78	900	0	0.0	25
7/29/91	13:42	78	850	0	0.0	25
7/29/91	13:45	78	800	0	0.0	25
7/29/91	13:49	78	900	0	0.0	25
7/29/91	13:50	78	875	0	0.0	0
7/29/91	14:00	78	850	0	0.0	25
7/29/91	14:02	78	850	5.05	1.1	25
7/29/91	14:15	78	1000	4	1.0	20
7/29/91	14:30	78	900	4	1.0	20
7/29/91	14:35	78	900	5.05	1.1	25
7/29/91	14:36	78	1000	5.05	1.1	25
7/29/91	14:45	78	900	5.05	1.1	25
7/29/91	15:00	78	890	5.05	1.1	25
7/29/91	15:15	78	900	5.05	1.1	25
7/29/91	16:10	78	900	5.05	1.1	25
7/29/91	16:30	78	910	5.05	1.1	25
7/29/91	19:30	78	900	5.05	1.1	25
7/29/91	20:30	78	925	5.05	1.0	28
7/29/91	21:30	78	925	5.05	1.0	28
7/29/91	22:30	78	910	5.05	1.0	28
7/29/91	23:30	78	910	5.05	1.0	28
7/30/91	00:30	78	910	5.05	1.0	28
7/30/91	01:30	78	900	5.05	1.0	28
7/30/91	02:30	78	900	5.05	1.0	28
7/30/91	03:30	78	900	5.05	1.0	28
7/30/91	04:30	77	900	5.05	1.0	28
7/30/91	05:30	77	910	5.05	1.0	28
7/30/91	06:30	77	925	5.05	1.0	28
7/30/91	07:30	77	925	5.05	1.0	28
7/30/91	09:30	77	925	5.05	1.0	28
7/30/91	09:45	77	925	5.05	1.2	21
7/30/91	10:00	77	925	5.05	1.2	21
7/30/91	10:30	77	940	5.05	1.2	21
7/30/91	11:30	77	930	5.05	1.2	21
7/30/91	12:30	77	940	5.05	1.2	21
7/30/91	13:30	77	945	5.05	1.2	21
7/30/91	14:00	77	940	5.05	1.0	30.5
7/30/91	14:30	77	940	5.05	1.0	30.5
7/30/91	15:30	77	945	5.05	1.0	30.5
7/30/91	16:00	77	940	5.05	0.9	38
7/30/91	16:30	77	960	5.05	0.9	38
7/30/91	17:00	77	1050	5.05	0.9	38
7/30/91	17:30	77	1090	5.05	0.9	38
7/30/91	18:30	77	1100	5.05	0.9	38

K5 FOAM TEST - PHASE I - INJECTION DATA

DATE	TIME	STEAM m3/d	WHP kPa	CHEMICAL l/m	CONCENTRATION %	WATER l/m
7/30/91	18:45	77	1100	5.05	0.9	38
7/30/91	19:30	77	1100	5.05	0.9	38
7/30/91	20:30	77	1100	5.05	0.8	40
7/30/91	21:30	77	950	5.05	0.8	40
7/30/91	22:30	77	950	5.05	0.9	38
7/30/91	23:30	77	950	5.05	0.9	38
7/31/91	00:30	77	1040	5.05	0.9	36
7/31/91	01:30	77	1100	5.05	0.9	36
7/31/91	02:30	77	1100	5.05	0.9	36
7/31/91	03:30	77	1100	5.05	0.9	36
7/31/91	04:30	77	1100	5.05	0.9	36
7/31/91	05:30	77	1100	5.05	0.9	36
7/31/91	06:30	77	1100	5.05	0.9	36
7/31/91	07:30	77	1100	5.05	0.9	36
7/31/91	08:30	77	1120	5.05	0.9	36
7/31/91	09:30	77	1145	5.05	0.9	34
7/31/91	10:30	77	1110	5.05	1.0	30
7/31/91	11:30	77	1050	5.05	1.0	30
7/31/91	12:30	77	1100	5.05	1.0	30
7/31/91	13:00	77	1160	5.05	1.0	30
7/31/91	13:30	77	1160	5.05	1.0	30
7/31/91	14:00	77	1050	5.05	1.0	30
7/31/91	14:03	77	1040	4.04	0.8	30
7/31/91	14:30	77	1040	4.04	0.8	30
7/31/91	15:00	77	1040	4.04	0.8	30
7/31/91	15:42	107	1040	6.45	1.0	37
7/31/91	16:00	107	1320	6.45	1.0	37
7/31/91	16:30	107	1350	6.45	1.0	37
7/31/91	17:00	107	1350	6.45	1.0	37
7/31/91	17:30	107	1360	6.45	1.0	37
7/31/91	18:00	107	1360	5.05	0.9	28
7/31/91	18:30	107	1210	5.05	0.9	28
7/31/91	19:00	107	1200	5.05	0.9	28
7/31/91	19:30	107	1200	5.05	0.9	28
7/31/91	20:30	107	1200	5.05	0.9	28
7/31/91	21:30	107	1200	5.05	0.8	30
7/31/91	22:30	107	1200	5.05	0.8	30
7/31/91	23:30	107	1200	5.05	0.8	30
8/1/91	00:30	107	1210	3.5	0.7	21
8/1/91	01:30	107	1210	3.5	0.7	21
8/1/91	02:30	107	1210	5.05	1.0	21
8/1/91	03:00	107	1350	5.05	1.0	21
8/1/91	03:30	107	1350	5.05	0.8	30
8/1/91	04:30	107	1375	5.05	0.8	30
8/1/91	04:45	107	1375	5.05	0.8	30
8/1/91	05:30	107	1410	6.45	1.1	30

K5 FOAM TEST - PHASE I - INJECTION DATA

DATE	TIME	STEAM m3/d	WHP kPa	CHEMICAL l/m	CONCENTRATION %	WATER l/m
8/1/91	06:30	107	1400	6.45	1.0	35
8/1/91	07:30	107	1440	6.45	1.0	35
8/1/91	08:00	107	1430	5.05	1.0	21
8/1/91	08:30	107	1260	5.05	1.0	21
8/1/91	09:00	107	1260	3.5	0.7	18
8/1/91	09:30	107	1260	3.5	0.7	18
8/1/91	10:00	107	1260	3.5	0.7	18
8/1/91	10:30	107	1300	3.5	0.7	18
8/1/91	11:00	107	1340	3.5	0.7	18
8/1/91	12:00	107	1350	3.5	0.7	18
8/1/91	12:30	107	1350	3	0.6	18
8/1/91	13:00	107	1350	3	0.6	18
8/1/91	13:30	107	1350	3	0.6	18
8/1/91	14:00	107	1350	3	0.6	18
8/1/91	15:00	107	1350	2.5	0.5	18
8/1/91	15:30	107	1350	2.5	0.5	18
8/1/91	16:00	100	1350	2.5	0.5	18
8/1/91	16:30	100	1350	2.5	0.5	18
8/1/91	17:30	100	1350	2.5	0.5	18
8/1/91	18:00	100	1350	2.5	0.5	18
8/1/91	18:30	100	1350	2.5	0.5	18
8/1/91	19:00	100	1350	2.5	0.5	18
8/1/91	19:30	100	1350	2.5	0.5	18
8/1/91	20:30	100	1350	2.5	0.5	18
8/1/91	21:30	100	1350	2.5	0.5	18
8/1/91	22:00	100	1350	2	0.5	12
8/1/91	22:30	100	1350	2	0.5	12
8/1/91	23:30	100	1350	2	0.5	12
8/2/91	00:30	100	1350	2	0.5	12
8/2/91	01:30	100	1350	2	0.5	12
8/2/91	02:30	100	1350	2	0.5	12
8/2/91	03:30	95	1350	2	0.5	12
8/2/91	04:30	90	1350	2	0.5	12
8/2/91	05:30	90	1350	2	0.5	12
8/2/91	06:30	90	1350	2	0.5	12
8/2/91	07:00	90	1350	1.4	0.6	0
8/2/91	07:30	90	1350	1.4	0.6	0
8/2/91	09:30	90	1350	1.4	0.6	0
8/2/91	10:30	90	1360	1.4	0.6	0
8/2/91	12:30	90	1360	1.4	0.6	0
8/2/91	14:30	90	1365	1.4	0.6	0
8/2/91	15:45	90	1360	1.4	0.6	0
8/2/91	16:00	90	1200	1.4	0.6	0
8/2/91	16:15	90	1250	1.4	0.6	0
8/2/91	16:20	90	1320	1.4	0.6	0
8/2/91	18:00	90	1360	1.4	0.6	0

K5 FOAM TEST - PHASE I - INJECTION DATA

DATE	TIME	STEAM m3/d	WHP kPa	CHEMICAL l/m	CONCENTRATION %	WATER l/m
8/2/91	20:00	90	1360	1.4	0.6	0
8/2/91	22:00	90	1360	1.4	0.6	0
8/2/91	00:00	90	1350	1.4	0.6	0
8/2/91	02:00	90	1350	1.4	0.6	0
8/2/91	04:00	90	1340	1.4	0.6	0
8/3/91	06:00	85	1330	1.4	0.6	0
8/3/91	08:00	81	1330	1.4	0.6	0
8/3/91	09:00	77	1330	1.4	0.7	0
8/3/91	10:00	75	1310	1.4	0.7	0
8/3/91	11:00	75	1290	1.4	0.7	0
8/3/91	13:00	80	1300	1.4	0.6	0
8/3/91	15:00	80	1340	1.4	0.6	0
8/3/91	16:00	80	1340	1	0.5	0
8/3/91	18:00	80	1340	1	0.5	0
8/3/91	20:00	80	1340	1	0.5	0
8/3/91	22:00	80	1340	1	0.5	0
8/4/91	00:00	80	1330	1	0.5	0
8/4/91	02:00	90	1330	1	0.4	0
8/4/91	04:00	100	1320	1	0.4	0
8/4/91	06:00	100	1310	1	0.4	0
8/4/91	08:00	100	1300	1	0.4	0
8/4/91	09:00	100	1300	1	0.4	0
8/4/91	11:00	90	1300	1	0.4	0
8/4/91	13:00	90	1300	1	0.4	0
8/4/91	15:00	80	1300	1	0.5	0
8/4/91	17:00	80	1300	1	0.5	0
8/4/91	19:00	80	1300	1	0.5	0
8/4/91	21:00	75	1300	1	0.5	0
8/4/91	23:00	75	1300	1	0.5	0
8/5/91	01:00	75	1300	1	0.5	0
8/5/91	03:00	70	1300	1	0.5	0
8/5/91	05:00	70	1300	1	0.5	0
8/5/91	07:00	70	1300	1	0.5	0
8/5/91	09:00	70	1300	1	0.5	0
8/5/91	10:00	100	1300	1	0.4	0
8/5/91	12:00	100	1300	1	0.4	0
8/5/91	16:00	100	1300	1	0.4	0
8/5/91	20:00	100	1300	1	0.4	0
8/6/91	00:00	100	1300	1	0.4	0
8/6/91	04:00	100	1300	1	0.4	0
8/6/91	08:00	100	1300	1	0.4	0
8/6/91	12:00	90	1300	1	0.4	0
8/6/91	16:00	80	1300	1	0.5	0
8/6/91	20:00	77	1300	1	0.5	0
8/7/91	00:00	77	1300	1	0.5	0
8/7/91	04:00	77	1300	1	0.5	0

K5 FOAM TEST - PHASE I - INJECTION DATA

DATE	TIME	STEAM m3/d	WHP kPa	CHEMICAL l/m	CONCENTRATION %	WATER l/m
8/7/91	08:00	77	1300	1	0.5	0
8/7/91	12:00	74	1300	1	0.5	0
8/7/91	16:00	74	1310	1	0.5	0
8/7/91	20:00	74	1300	1	0.5	0
8/8/91	00:00	74	1300	1	0.5	0
8/8/91	04:00	73	1300	1	0.5	0
8/8/91	08:00	73	1300	0.6	0.3	0
8/8/91	12:00	73	1300	0.6	0.3	0
8/8/91	16:00	73	1300	0.6	0.3	0
8/8/91	20:00	73	1300	0.6	0.3	0
8/9/91	10:00	73	1300	0.6	0.3	0
8/10/91	10:00	79	1270	0.6	0.3	0
8/11/91	10:00	72	1280	0.6	0.3	0
8/12/91	10:00	80	1280	0.6	0.3	0
8/12/91	15:30	80	1290	0	0.0	0
8/13/91	09:00	77	1100	0.6	0.3	0
8/13/91	11:30	78	1200	0.6	0.3	0
8/13/91	12:00	78	1240	0.6	0.3	0
8/13/91	14:00	79	1300	0.6	0.3	0
8/13/91	16:00	80	1310	0	0.0	0
8/13/91	16:15	80	1100	0	0.0	0
8/13/91	17:00	81	1300	0	0.0	0
8/13/91	22:00	82	1310	0	0.0	0
8/14/91	02:00	80	1310	0	0.0	0
8/14/91	08:30	77	1310	0.6	0.3	0
8/14/91	12:00	77	1300	0.6	0.3	0
8/14/91	16:00	77	1300	0	0.0	0
8/15/91	00:00	77	1300	0	0.0	0
8/15/91	08:00	71	1300	0	0.0	0
8/15/91	12:00	71	1300	0.6	0.3	0
8/15/91	16:00	71	1300	0.6	0.3	0
8/16/91	00:00	71	1300	0	0.0	0
8/16/91	08:00	70	1310	0.6	0.3	0
8/16/91	12:00	70	1310	0.6	0.3	0
8/16/91	16:00	70	1310	0	0.0	0
8/17/91	00:00	70	1310	0	0.0	0
8/17/91	08:00	72	1310	0.6	0.3	0
8/17/91	12:00	72	1310	0.6	0.3	0
8/17/91	16:00	72	1310	0	0.0	0
8/18/91	00:00	72	1310	0.6	0.3	0
8/18/91	08:00	71	1310	0.6	0.3	0
8/18/91	12:00	71	1310	0	0.0	0
8/18/91	16:00	71	1310	0	0.0	0
8/19/91	00:00	71	1310	0	0.0	0
9/19/91	08:30	75	1320	0.6	0.3	0
9/19/91	15:00	75	1340	0	0.0	0

K5 FOAM TEST - PHASE I - INJECTION DATA

DATE	TIME	STEAM m3/d	WHP kPa	CHEMICAL l/m	CONCENTRATION %	WATER l/m
8/20/91	12:00	75	1280	0.6	0.3	0
8/20/91	15:00	75	1300	0	0.0	0
8/21/91	10:00	76	1280	0.6	0.3	0
8/21/91	15:30	76	1320	0	0.0	0
8/22/91	08:30	73	1280	0.6	0.3	0
8/22/91	15:30	73	1320	0	0.0	0
8/23/91	08:30	79	1280	0.6	0.3	0
8/23/91	14:30	79	1320	0	0.0	0
8/24/91	08:30	70	1300	0.6	0.3	0
8/24/91	16:00	70	1300	0	0.0	0
8/25/91	09:00	73	1280	0.6	0.3	0
8/25/91	15:30	73	1300	0	0.0	0
8/26/91	09:00	72	1300	0.6	0.3	0
8/26/91	16:00	72	1350	0	0.0	0
8/27/91	08:30	73	1320	0.6	0.3	0
8/27/91	15:30	73	1300	0	0.0	0
8/28/91	08:30	73	1350	0.6	0.3	0
8/28/91	14:00	73	1340	0	0.0	0
8/29/91	08:30	76	1250	0.6	0.3	0
8/29/91	14:00	76	1310	0	0.0	0
8/30/91	08:30	78	1350	0	0.0	0
8/31/91	08:30	72	1350	0	0.0	0
9/1/91	08:30	107	1100	0	0.0	0
9/2/91	08:30	107	1100	0	0.0	0
9/3/91	08:30	99	1000	0	0.0	0
9/4/91	08:30	100	950	0	0.0	0
9/5/91	08:30	71	900	0	0.0	0
9/6/91	08:30	94	1100	0	0.0	0
9/7/91	08:30	99	1100	0	0.0	0

Table 2

K14 FOAM TEST - PHASE I - INJECTION DATA

DATE	TIME	STEAM m3/d	WHP kPa	CHEMICAL l/m	CONCENTRATION %	WATER l/m
8/7/91	10:00	95	1260	4.7	1.0	20
8/7/91	10:15	95	1270	4.7	1.0	20
8/7/91	10:30	95	1290	4.7	1.0	20
8/7/91	11:00	95	1310	4.7	1.0	20
8/7/91	11:30	95	1360	4.7	1.0	20
8/7/91	12:00	95	1370	4.7	1.0	20
8/7/91	12:30	95	1400	4.7	1.0	20
8/7/91	13:00	95	1440	4.7	1.0	20
8/7/91	13:30	95	1490	4.7	1.0	20
8/7/91	14:30	100	1550	3.9	1.0	12
8/7/91	15:30	100	1610	3.9	1.0	12
8/7/91	16:30	100	1670	3.9	1.0	12
8/7/91	17:00	100	1710	3.9	1.0	12
8/7/91	17:30	100	1770	3.1	1.0	4
8/7/91	18:30	100	1770	3.1	1.0	4
8/7/91	19:30	100	1770	3.1	1.0	4
8/7/91	20:30	100	1780	3.1	1.0	4
8/7/91	21:30	100	1800	3.1	1.0	4
8/7/91	22:30	100	1825	2.7	1.0	0
8/7/91	23:00	100	1840	2.7	1.0	0
8/7/91	23:30	100	1850	2.7	1.0	0
8/8/91	00:30	100	1870	2.7	1.0	0
8/8/91	01:30	100	1890	2.7	1.0	0
8/8/91	03:00	100	1910	2.7	1.0	0
8/8/91	04:00	100	1930	2.7	1.0	0
8/8/91	05:00	100	1940	2.7	1.0	0
8/8/91	06:00	100	1940	2.7	1.0	0
8/8/91	07:00	100	1950	2.7	1.0	0
8/8/91	09:30	100	1950	2.7	1.0	0
8/8/91	11:00	100	1850	2.7	1.0	0
8/8/91	14:00	100	1850	2.7	1.0	0
8/8/91	20:00	100	1900	2.7	1.0	0
8/9/91	00:00	100	1850	2.7	1.0	0
8/9/91	12:00	99	1850	2.7	1.0	0
8/9/91	16:00	99	1850	2.7	1.0	0
8/9/91	19:00	99	1950	2.7	1.0	0
8/10/91	00:00	99	1850	2.7	1.0	0
8/10/91	08:00	98	1850	2.7	1.0	0
8/10/91	13:00	98	1850	1.4	0.5	0
8/11/91	00:00	98	1850	1.4	0.5	0
8/11/91	12:00	95	1850	1.4	0.5	0
8/11/91	18:00	95	1850	1.4	0.5	0
8/12/91	10:00	100	1850	1.4	0.5	0
8/12/91	16:00	100	1890	0	0.0	0

K14 FOAM TEST - PHASE I - INJECTION DATA

DATE	TIME	STEAM m3/d	WHP kPa	CHEMICAL l/m	CONCENTRATION %	WATER l/m
8/12/91	21:00	100	1880	0	0.0	0
8/13/91	00:00	100	1820	0	0.0	0
8/13/91	04:00	96	1790	0	0.0	0
8/13/91	08:00	96	1750	0	0.0	0
8/13/91	09:00	96	1750	1.4	0.5	0
8/13/91	10:00	70	1600	1.4	0.7	0
8/13/91	11:00	80	1750	1.4	0.6	0
8/13/91	12:00	87	1800	1.4	0.6	0
8/13/91	14:00	95	1840	1.4	0.5	0
8/13/91	16:00	70	1840	0	0.0	0
8/13/91	17:00	96	1940	0	0.0	0
8/13/91	18:00	100	2000	0	0.0	0
8/13/91	20:00	96	1940	0	0.0	0
8/13/91	22:00	96	1840	0	0.0	0
8/14/91	00:00	96	1790	0	0.0	0
8/14/91	04:00	96	1740	0	0.0	0
8/14/91	08:30	96	1710	1.4	0.5	0
8/14/91	12:00	96	1750	0.8	0.3	0
8/14/91	16:00	96	1800	0	0.0	0
8/14/91	18:00	96	1830	0	0.0	0
8/14/91	22:00	96	1790	0	0.0	0
8/15/91	02:00	96	1690	0	0.0	0
8/15/91	05:00	100	1660	0	0.0	0
8/15/91	08:00	108	1640	0.8	0.3	0
8/15/91	16:00	108	1790	0	0.0	0
8/15/91	20:00	108	1770	0	0.0	0
8/15/91	23:00	108	1710	0	0.0	0
8/16/91	04:00	108	1650	0	0.0	0
8/16/91	08:00	108	1620	0.8	0.3	0
8/16/91	10:00	108	1640	0.8	0.3	0
8/16/91	14:00	108	1690	0.8	0.3	0
8/16/91	16:00	108	1690	0	0.0	0
8/16/91	22:00	108	1730	0	0.0	0
8/17/91	02:00	108	1650	0	0.0	0
8/17/91	08:00	110	1620	0.8	0.3	0
8/17/91	14:00	110	1700	0.8	0.3	0
8/17/91	16:00	110	1720	0	0.0	0
8/17/91	22:00	110	1700	0	0.0	0
8/18/91	08:00	109	1620	0.8	0.3	0
8/18/91	16:00	109	1770	0	0.0	0
8/19/91	08:30	93	1620	0.8	0.3	0
8/19/91	15:00	93	1770	0	0.0	0
8/20/91	12:00	93	1690	0.8	0.3	0
8/20/91	15:00	93	1860	0	0.0	0
8/21/91	10:00	94	1595	0.8	0.3	0
8/21/91	15:30	94	1800	0	0.0	0

4/22/92

K14 FOAM TEST - PHASE I - INJECTION DATA

DATE	TIME	STEAM m3/d	WHP kPa	CHEMICAL l/m	CONCENTRATION %	WATER l/m
8/22/91	08:30	98	1680	0.8	0.3	0
8/22/91	15:30	98	1960	0	0.0	0
8/23/91	08:30	109	1690	0.8	0.3	0
8/23/91	14:30	109	1860	0	0.0	0
8/24/91	08:30	110	1650	0.8	0.3	0
8/24/91	16:00	110	1850	0	0.0	0
8/25/91	09:00	98	1650	0.8	0.3	0
8/25/91	15:30	98	1820	0	0.0	0
8/26/91	09:00	97	1680	0.8	0.3	0
8/26/91	14:00	97	2200	0.8	0.3	0
8/26/91	16:00	97	2140	0	0.0	0
8/27/91	08:30	98	1640	0.8	0.3	0
8/27/91	15:30	98	1850	0	0.0	0
8/28/91	08:30	97	1670	0.8	0.3	0
8/28/91	14:00	97	1810	0	0.0	0
8/29/91	08:30	121	1550	0.8	0.2	0
8/29/91	14:00	121	2150	0	0.0	0
8/30/91	14:00	119	1550	0	0.0	0
8/31/91	14:00	120	1550	0	0.0	0
9/1/91	14:00	120	1700	0	0.0	0
9/2/91	14:00	119	1700	0	0.0	0
9/3/91	14:00	104	1430	0	0.0	0
9/4/91	14:00	101	1350	0	0.0	0
9/5/91	14:00	85	1240	0	0.0	0
9/6/91	14:00	91	1330	0	0.0	0
9/7/91	14:00	94	1280	0	0.0	0

Table 3

K16 FOAM TEST - PHASE I - INJECTION DATA

DATE	TIME	STEAM m3/d	WHP kPa	CHEMICAL l/m	CONCENTRATION %	WATER l/m
8/2/91	09:30	94	1410	4.3	1.0	18
8/2/91	09:45	94	1420	4.3	1.0	18
8/2/91	10:00	94	1450	4.3	1.0	18
8/2/91	10:30	94	1560	3.9	0.9	18
8/2/91	11:00	94	1595	3.9	1.0	12
8/2/91	11:30	94	1650	3.9	1.0	12
8/2/91	12:00	94	1680	3.9	1.0	12
8/2/91	12:30	94	1740	3.9	1.0	12
8/2/91	13:00	94	1820	3.1	0.8	12
8/2/91	13:30	94	1840	3.1	1.0	4
8/2/91	14:00	94	1860	3.1	1.0	4
8/2/91	14:30	96	1910	3.1	1.0	4
8/2/91	15:00	90	1945	3.1	1.1	4
8/2/91	15:30	94	1900	3.1	1.0	4
8/2/91	16:00	97	2000	3.1	1.0	4
8/2/91	16:15	98	2000	2.7	1.0	0
8/2/91	16:30	98	2000	2.7	1.0	0
8/2/91	16:47	98	2000	2.7	1.0	0
8/2/91	17:00	98	2000	2.7	1.0	0
8/2/91	17:15	98	2000	2.7	1.0	0
8/2/91	17:30	98	2000	2.7	1.0	0
8/2/91	22:00	98	2050	2.7	1.0	0
8/3/91	04:00	98	2100	2.7	1.0	0
8/3/91	07:00	98	2220	2.7	1.0	0
8/3/91	07:30	98	2100	2.7	1.0	0
8/3/91	08:00	98	2250	2.7	1.0	0
8/3/91	09:30	98	2250	2.7	1.0	0
8/3/91	12:00	98	2250	2.7	1.0	0
8/4/91	00:00	98	2250	2.7	1.0	0
8/4/91	12:00	101	2140	1.4	0.5	0
8/4/91	18:00	101	2200	1.4	0.5	0
8/5/91	00:00	101	2190	1.4	0.5	0
8/5/91	08:00	98	2160	1.4	0.5	0
8/6/91	08:00	95	2160	1.4	0.5	0
8/7/91	08:00	100	2160	1.4	0.5	0
8/7/91	09:30	100	2350	1.4	0.5	0
8/7/91	10:30	100	2500	1	0.4	0
8/7/91	10:45	100	2050	1.4	0.5	0
8/7/91	14:30	100	2010	1.4	0.5	0
8/7/91	17:30	100	2060	1.4	0.5	0
8/7/91	18:30	100	2060	1.4	0.5	0
8/7/91	19:45	100	2060	1.4	0.5	0
8/7/91	21:30	100	2060	1.4	0.5	0
8/8/91	01:30	100	2100	1.4	0.5	0

K16 FOAM TEST - PHASE I - INJECTION DATA

DATE	TIME	STEAM m3/d	WHP kPa	CHEMICAL l/m	CONCENTRATION %	WATER l/m
8/8/91	06:00	100	2120	1.4	0.5	0
8/9/91	08:00	99	2100	0.8	0.3	0
8/10/91	08:00	98	2100	0.8	0.3	0
8/11/91	11:00	95	2140	0.8	0.3	0
8/12/91	10:00	100	2160	0.8	0.3	0
8/12/91	15:30	100	2160	0.8	0.3	0
8/12/91	16:00	100	2140	0	0.0	0
8/12/91	18:00	100	2070	0	0.0	0
8/13/91	00:00	100	1970	0	0.0	0
8/13/91	08:00	96	1870	0	0.0	0
8/13/91	09:00	75	1750	0.8	0.4	0
8/13/91	10:00	96	1970	0.8	0.3	0
8/13/91	12:00	96	2000	0.8	0.3	0
8/13/91	16:00	80	2070	0	0.0	0
8/13/91	17:00	96	2170	0	0.0	0
8/13/91	19:00	96	2070	0	0.0	0
8/13/91	22:00	96	1970	0	0.0	0
8/14/91	04:00	96	1950	0	0.0	0
8/14/91	08:30	96	1910	0.8	0.3	0
8/14/91	09:00	96	2140	0.8	0.3	0
8/14/91	10:00	96	2200	0.8	0.3	0
8/14/91	12:00	96	2270	0.8	0.3	0
8/14/91	14:00	96	2340	0.8	0.3	0
8/14/91	16:00	96	2370	0	0.0	0
8/14/91	18:00	96	2190	0	0.0	0
8/15/91	00:00	96	2070	0	0.0	0
8/15/91	07:00	93	2000	0.8	0.3	0
8/15/91	08:00	93	2270	0.8	0.3	0
8/15/91	13:00	93	2470	0.8	0.3	0
8/15/91	16:00	93	2470	0	0.0	0
8/15/91	17:30	93	2370	0	0.0	0
8/15/91	18:30	93	2270	0	0.0	0
8/15/91	22:00	93	2100	0	0.0	0
8/16/91	03:00	93	2070	0	0.0	0
8/16/91	08:30	92	2000	0.8	0.3	0
8/16/91	10:00	92	2250	0.8	0.3	0
8/16/91	15:00	92	2500	0.8	0.3	0
8/16/91	16:00	92	2470	0	0.0	0
8/16/91	20:00	92	2200	0	0.0	0
8/17/91	04:00	92	2100	0	0.0	0
8/17/91	08:00	94	2100	0.8	0.3	0
8/17/91	15:00	94	2450	0.8	0.3	0
8/17/91	16:00	94	2420	0	0.0	0
8/18/91	08:00	94	2100	0.8	0.3	0
8/18/91	16:00	94	2400	0	0.0	0
8/19/91	08:00	93	2100	0.8	0.3	0

K16 FOAM TEST - PHASE I - INJECTION DATA

DATE	TIME	STEAM m3/d	WHP kPa	CHEMICAL l/m	CONCENTRATION %	WATER l/m
8/19/91	15:00	93	2820	0	0.0	0
8/20/91	12:00	93	2020	0.8	0.3	0
8/20/91	15:00	93	2560	0	0.0	0
8/21/91	10:00	94	2000	0.8	0.3	0
8/21/91	15:30	94	2700	0	0.0	0
8/22/91	08:30	98	2110	0.8	0.3	0
8/22/91	15:30	98	2800	0	0.0	0
8/23/91	08:30	76	2140	0.8	0.4	0
8/23/91	14:30	76	2820	0	0.0	0
8/24/91	08:30	76	2140	0.8	0.4	0
8/24/91	16:00	76	2830	0	0.0	0
8/25/91	09:00	98	2150	0.8	0.3	0
8/25/91	15:30	98	3050	0	0.0	0
8/26/91	09:00	97	2140	0.8	0.3	0
8/26/91	14:00	97	2850	0.8	0.3	0
8/26/91	16:00	97	2940	0	0.0	0
8/27/91	08:30	98	2240	0.8	0.3	0
8/27/91	15:30	98	2800	0	0.0	0
8/28/91	08:30	106	2300	0.8	0.3	0
8/28/91	14:00	106	2950	0	0.0	0
8/29/91	08:00	95	2100	0.8	0.3	0
8/29/91	16:00	95	2750	0	0.0	0
8/30/91	14:00	94	2000	0	0.0	0
8/31/91	14:00	95	1650	0	0.0	0
9/1/91	14:00	94	1950	0	0.0	0
9/2/91	14:00	94	1950	0	0.0	0
9/3/91	14:00	97	1740	0	0.0	0
9/4/91	14:00	94	1800	0	0.0	0
9/5/91	14:00	87	1680	0	0.0	0
9/6/91	14:00	88	1800	0	0.0	0
9/7/91	14:00	94	1750	0	0.0	0

Table 4

K PAD FOAM TEST - PHASE I

TOTAL DISSOLVED SOLIDS DATA

DATE	K1 mg/l	K2 mg/l	K3 mg/l	K4 mg/l	K6 mg/l	K7 mg/l	K8 mg/l	K10 mg/l	K11 mg/l	K12 mg/l	K13 mg/l	K15 mg/l	K17 mg/l	V16 mg/l	V17 mg/l	V18 mg/l	V19 mg/l	V20 mg/l
24-Jul-91	7210	9050	6455	7775	13910	6540	4570	2850	5505	5840	5250	4000	5240		7025		5290	
26-Jul-91	7290	10180	6950	8240	7140	7270	5221	3878	5650	6680	4400	4410	5330	12980	8600		6810	
27-Aug-91	6892	10514	11204	8020	7564	8534	7048		6260	6390	3816	3890	5496	12452	7512		9342	6912
15-Oct-91	5620	9976	9697	5512	8268	6013	4300	3773	5860		2260	3938	5855		7950			5280
29-Oct-91	6300	18346	13908	10252	8330	9426	8004		6942	5092	5450	3568	17034		11946			5144
21-Nov-91	6500	10364	9722	7302	7307	7423	5280	4860	6998	6076	4252	3570	4938	12440	6014			6992

4/22/92

FIGURES

Figure 1
TYPE LOG

K-14

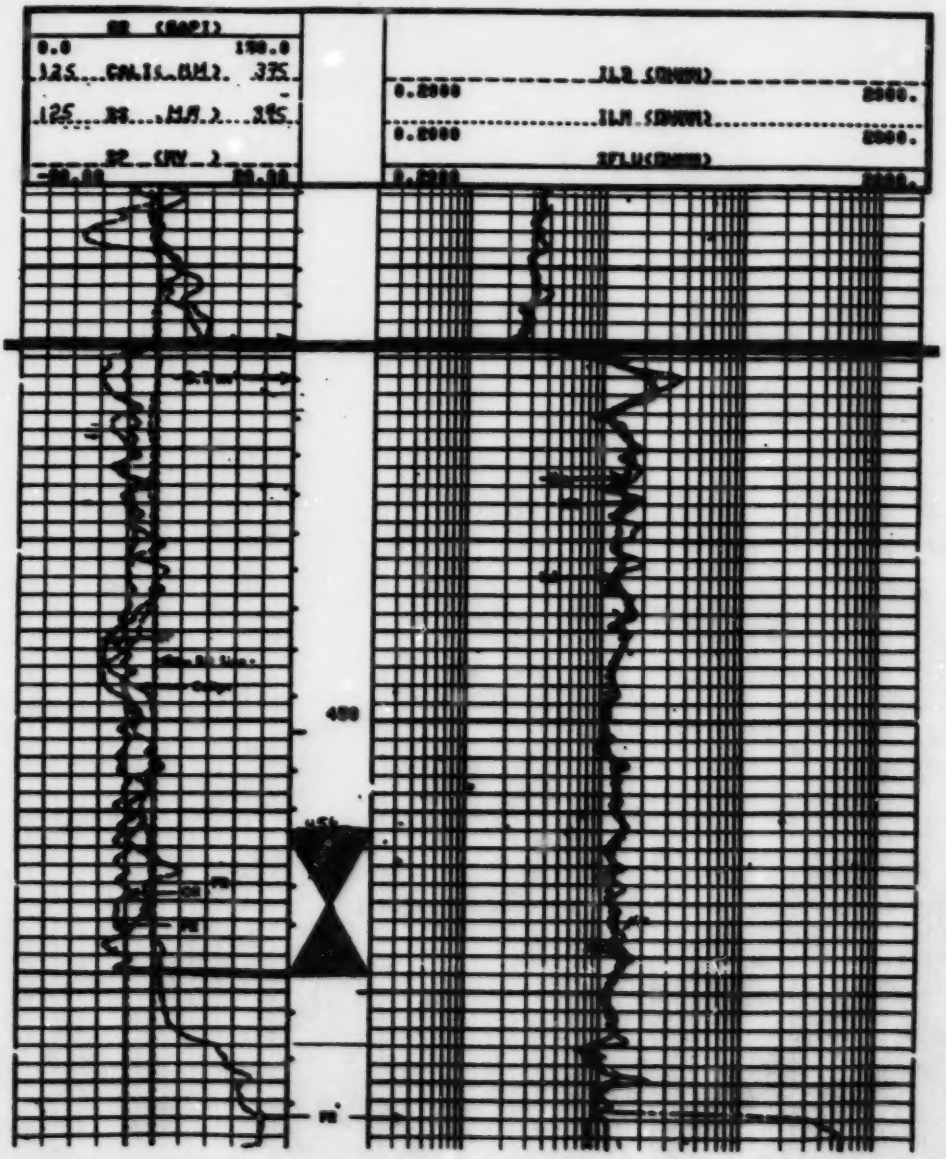


Figure 2

K PAD & V PAD ROW 4

DBA/sc
920210

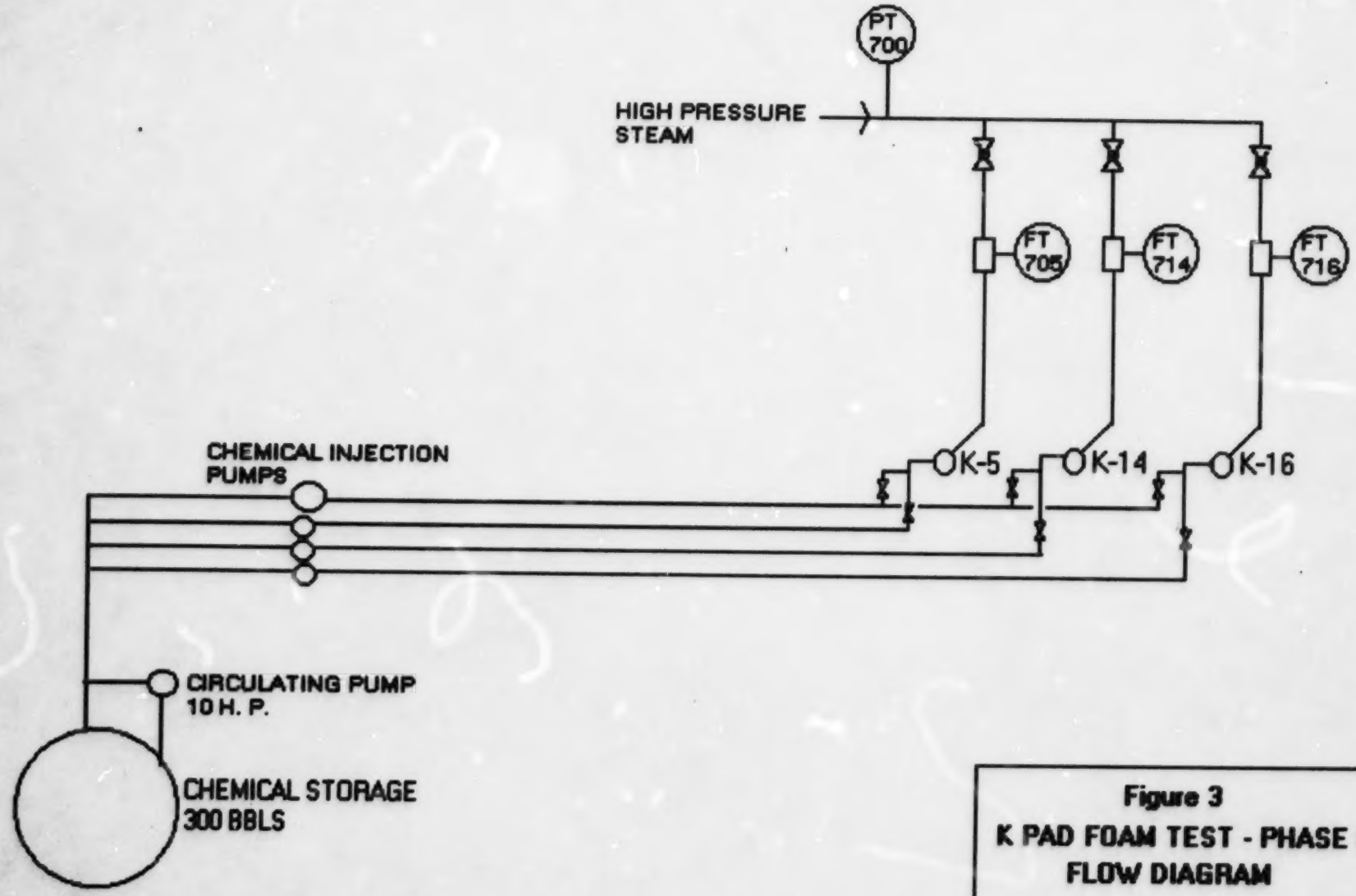
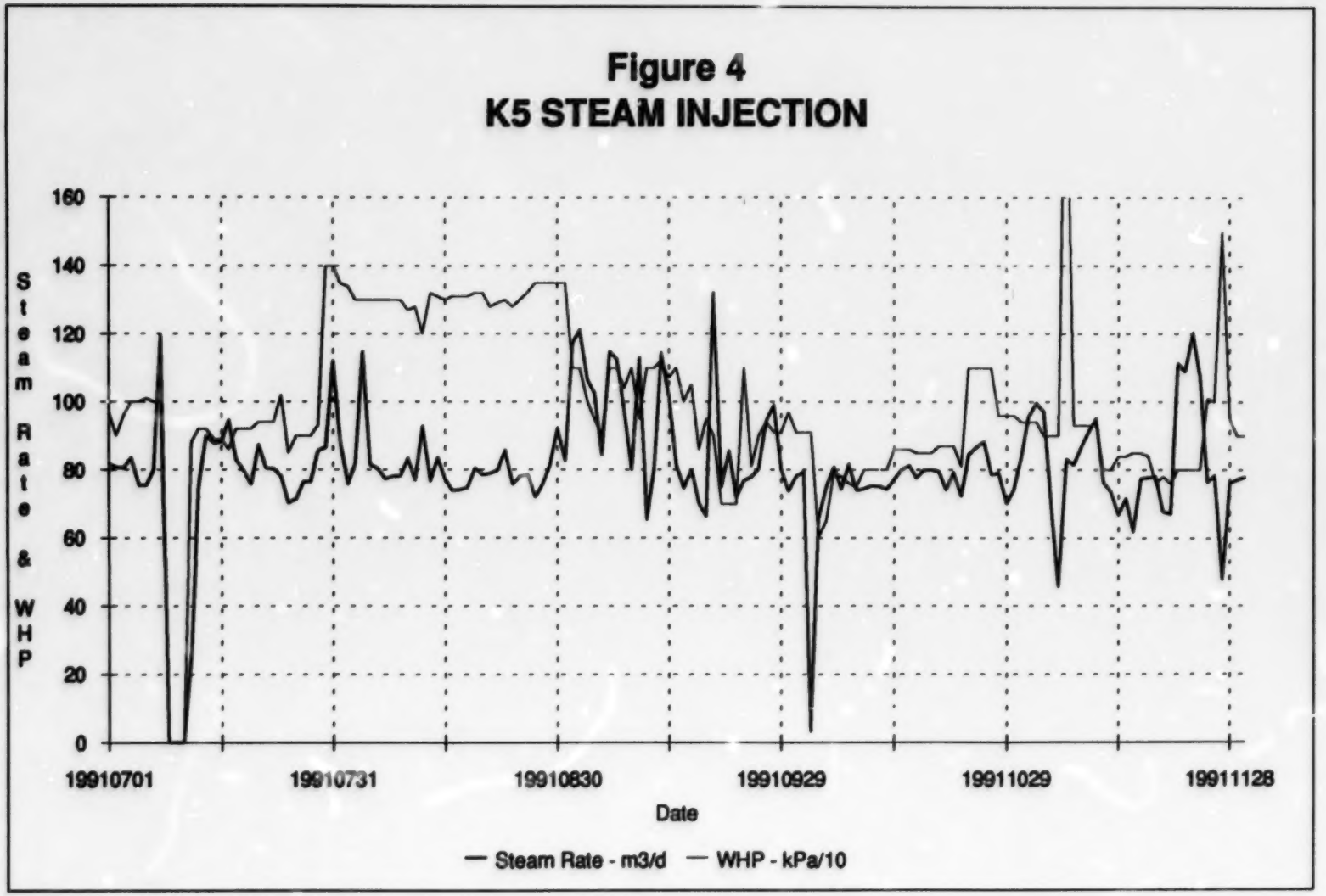


Figure 3
K PAD FOAM TEST - PHASE I
FLOW DIAGRAM

91-11-14 LAS

Figure 4
K5 STEAM INJECTION



4/21/92

Figure 5a

K5 FOAM TEST - PHASE I - INJECTION DATA

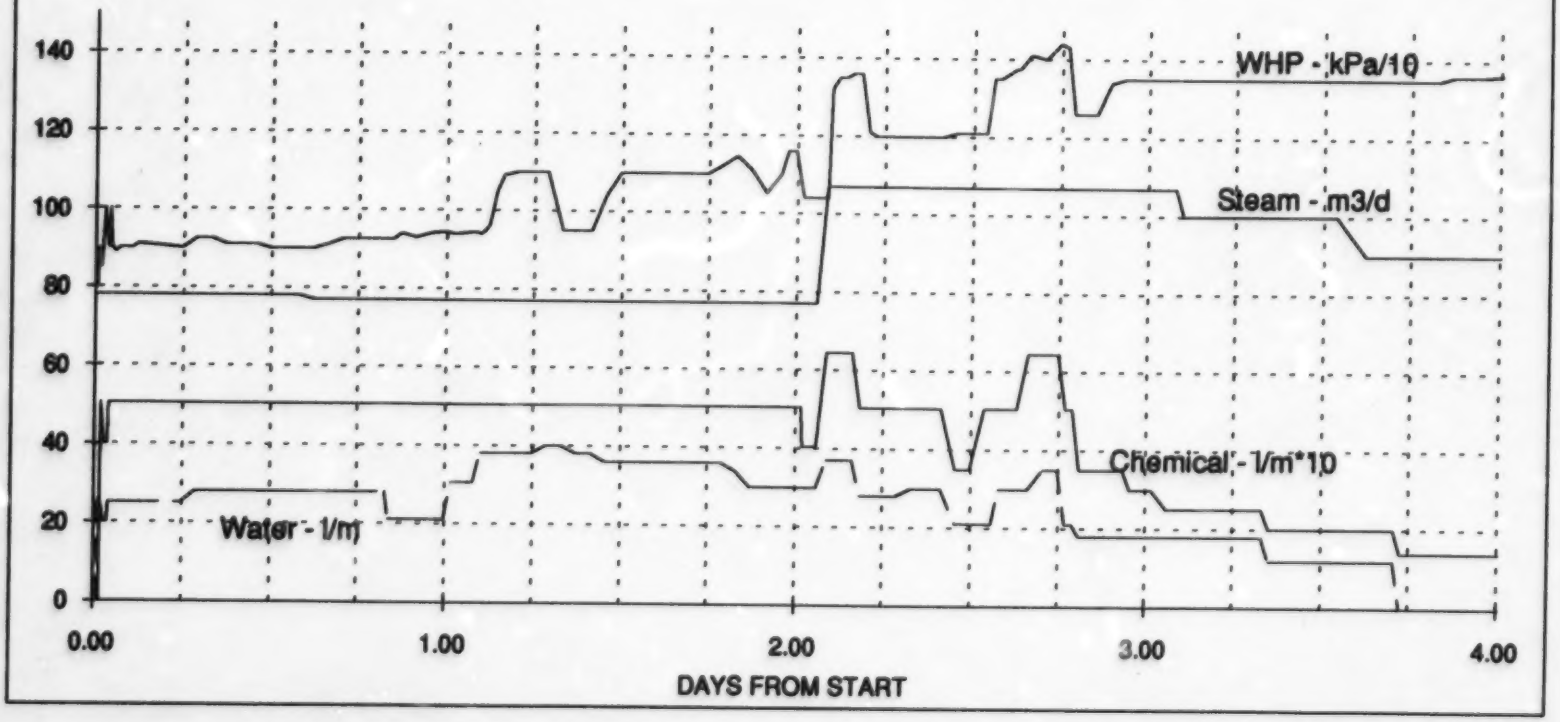


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Figure 5b

K5 FOAM TEST - PHASE I - INJECTION DATA

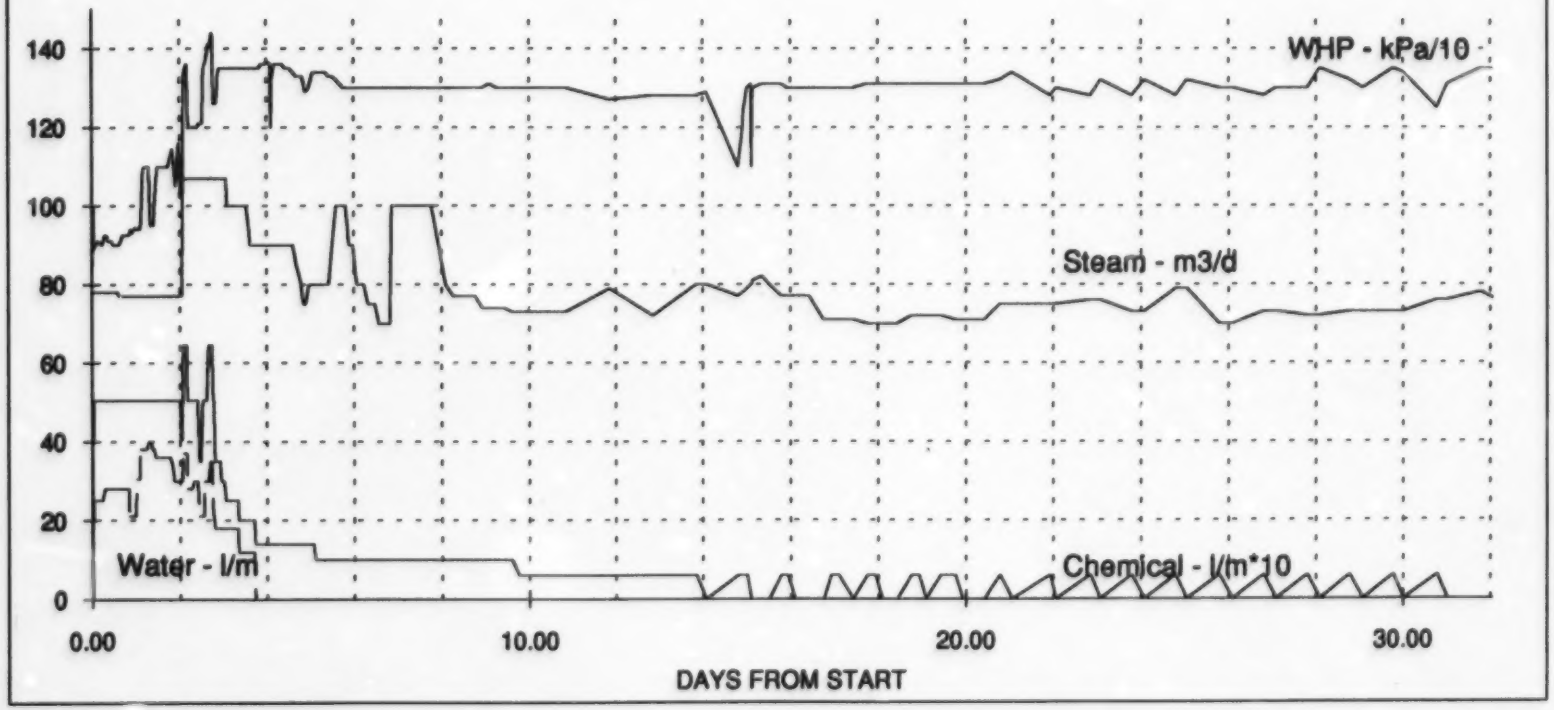

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Figure 6
K14 STEAM INJECTION

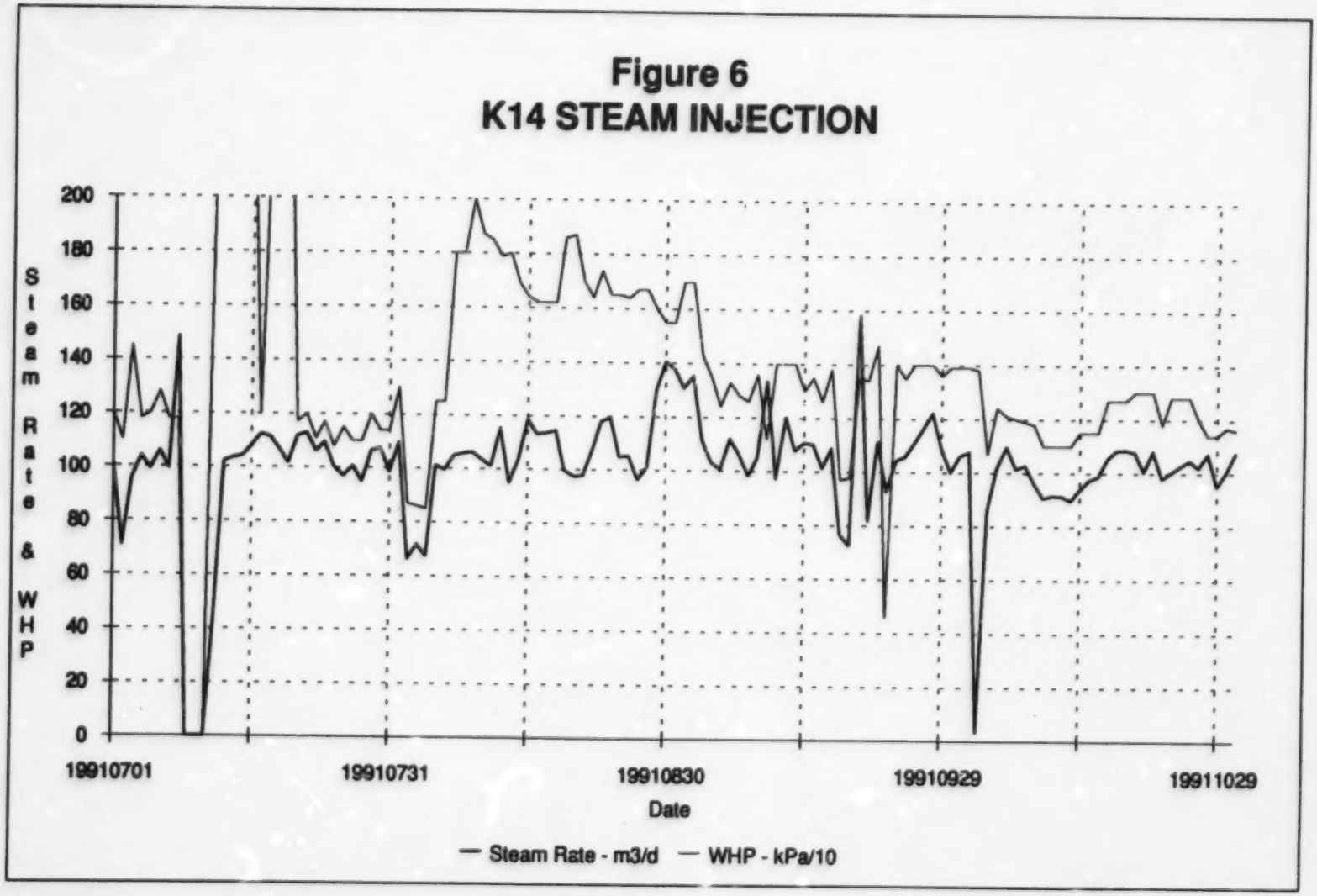

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Figure 7a

K14 FOAM TEST - PHASE I - INJECTION DATA

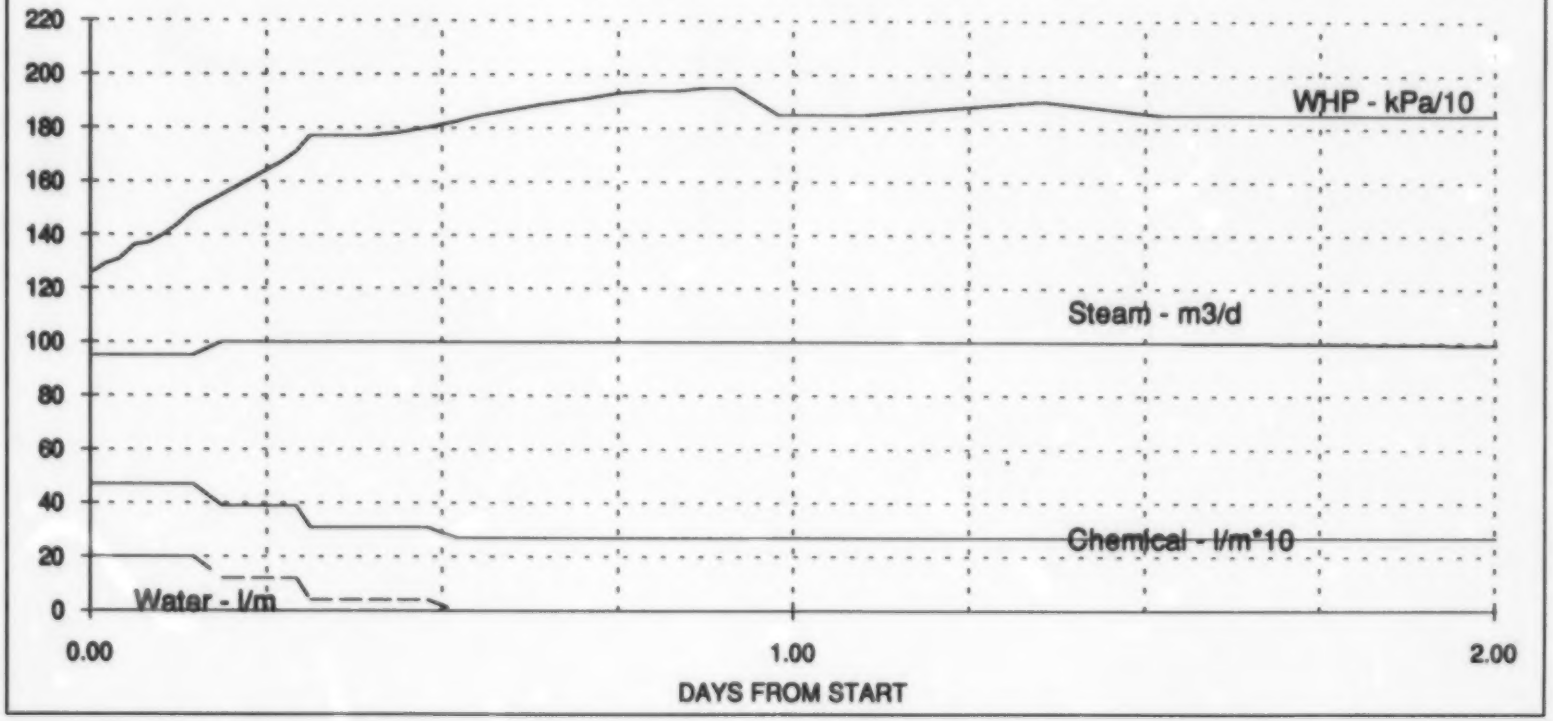

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Figure 7b

K14 FOAM TEST - PHASE I - INJECTION DATA

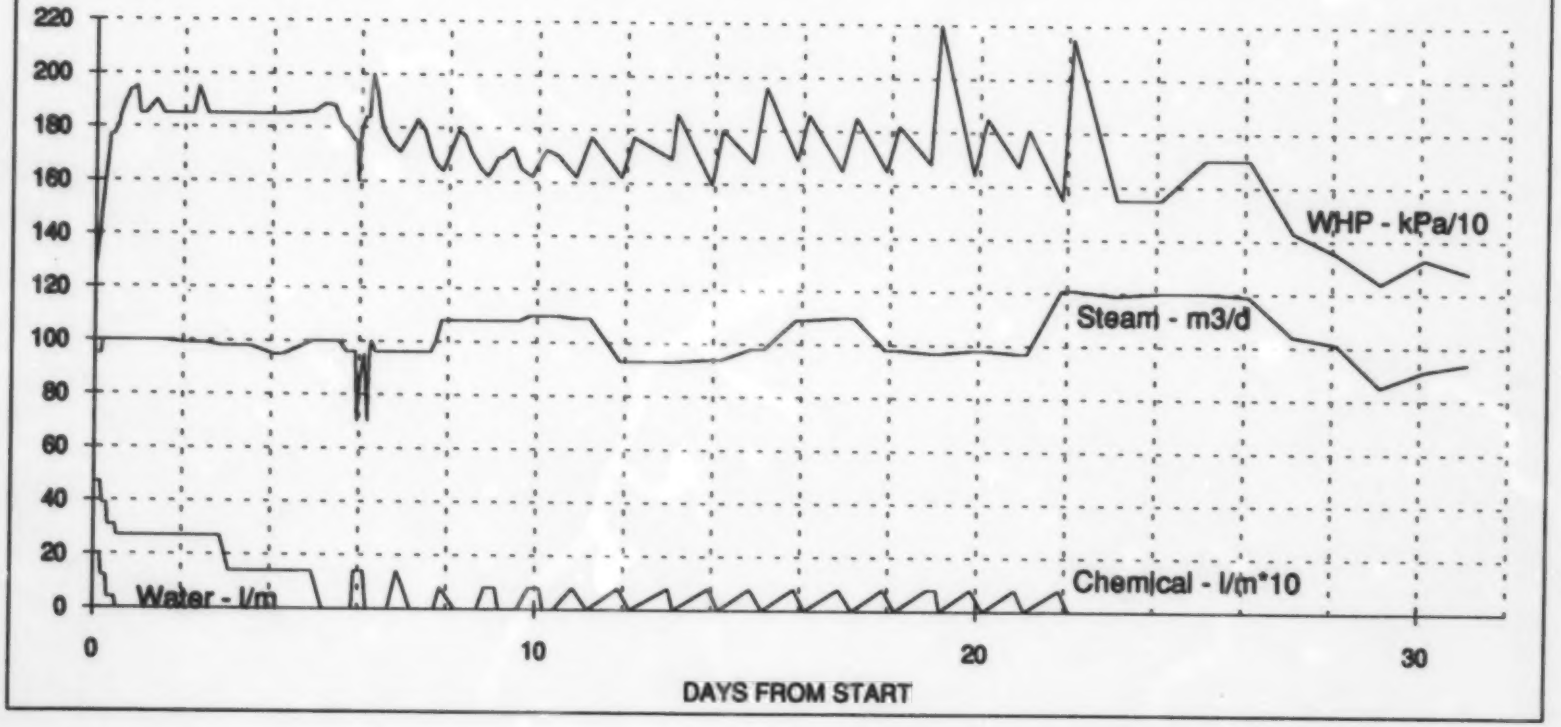

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Figure 8
K16 STEAM INJECTION

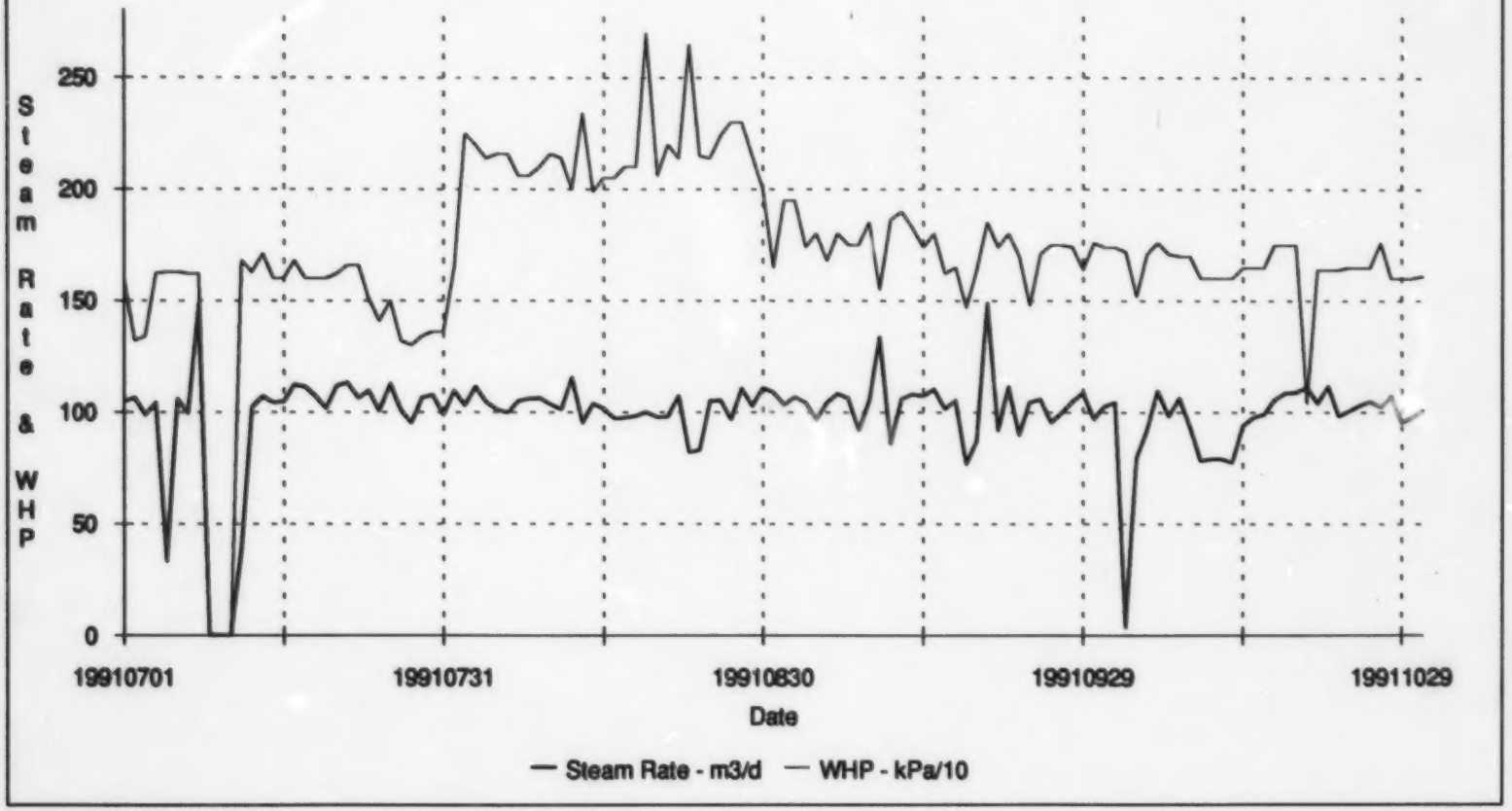

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Figure 9a

K16 FOAM TEST - PHASE I - INJECTION DATA

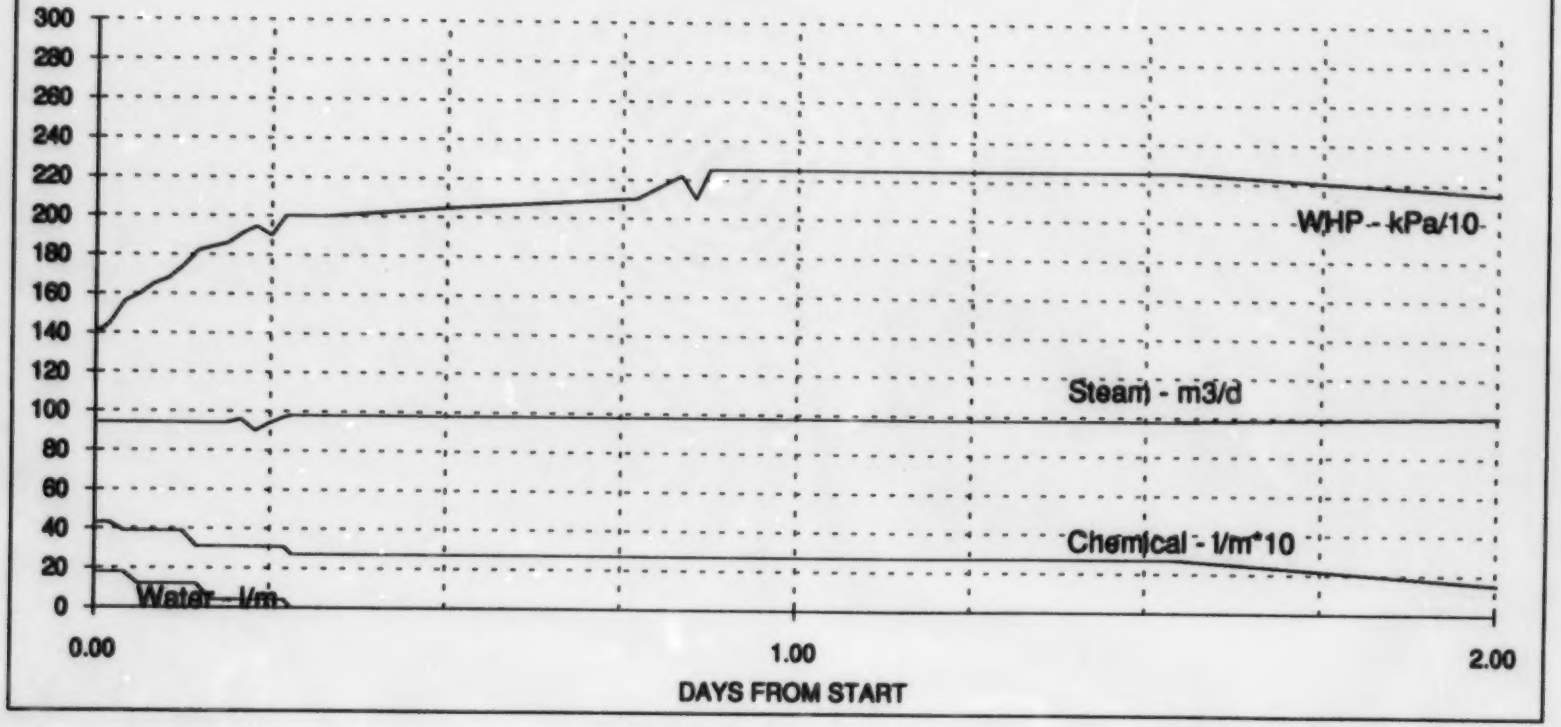

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Figure 9b

K16 FOAM TEST - PHASE I - INJECTION DATA

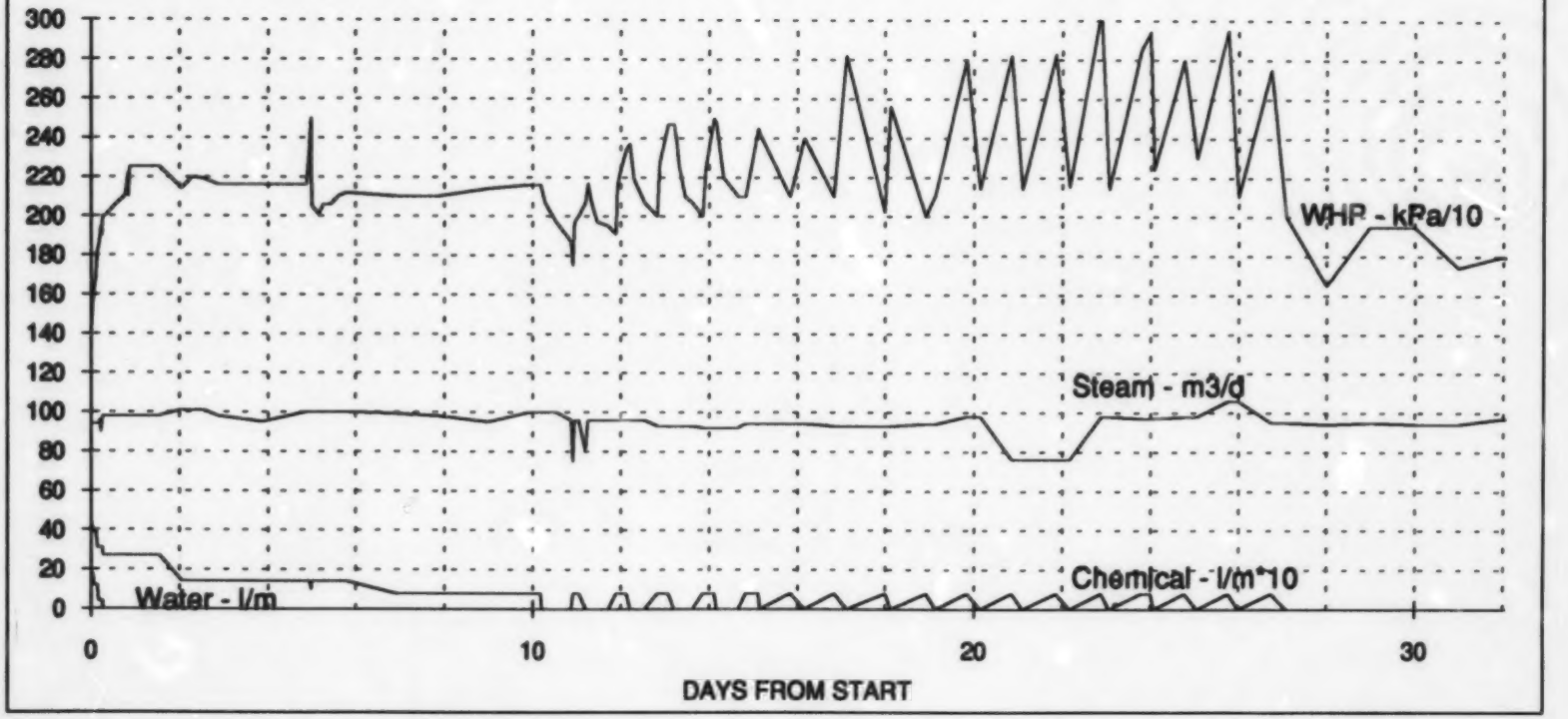

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Figure 10
K9 STEAM INJECTION

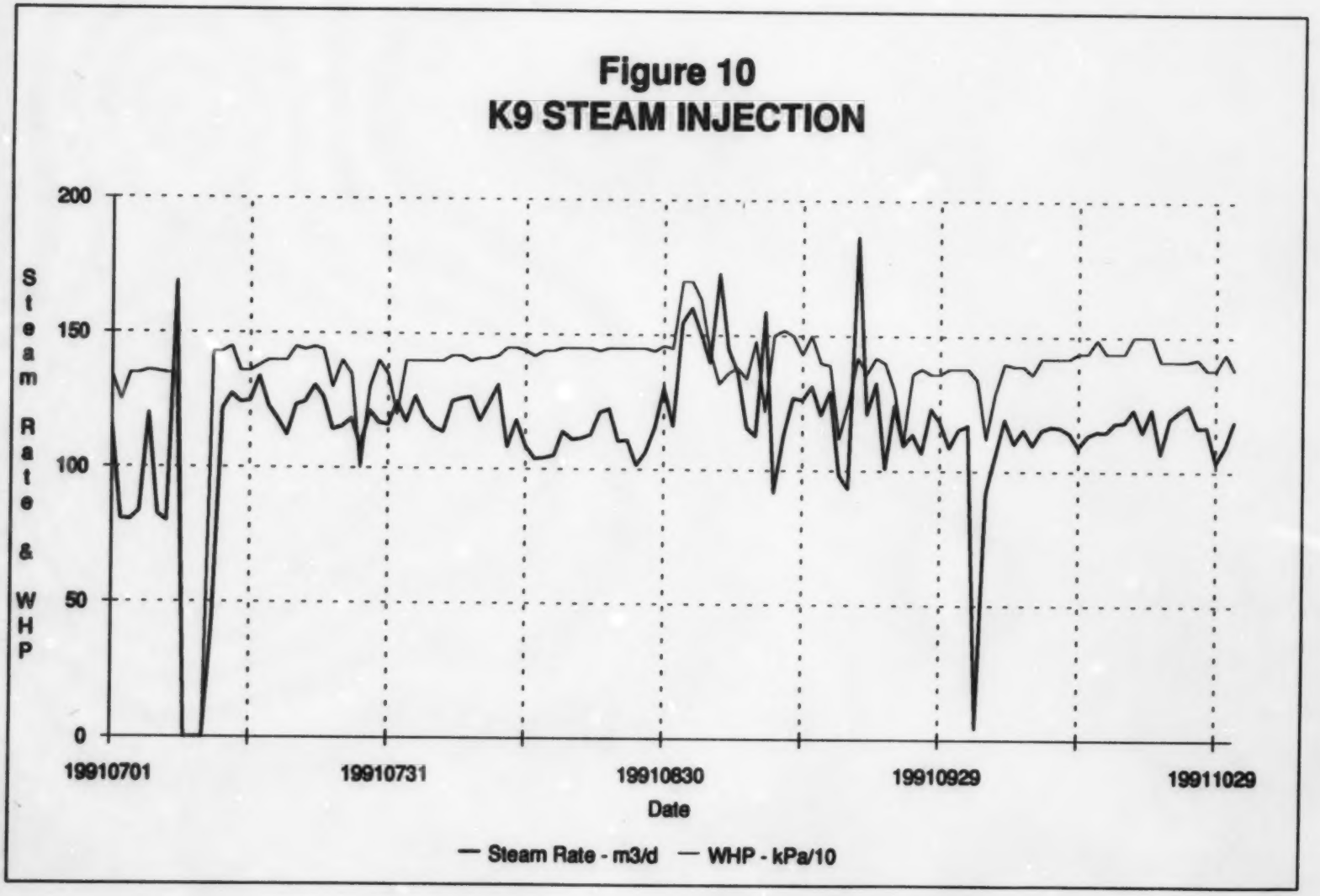

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FIGURE 11

K7 PRODUCTION PLOT

OIL TEST WATER TEST PUMPCAP CASING/20 TOTFLUID WHTEMP
200+50*OILCUT 250+50*CHOKE
COMMON_NAME=00K-07

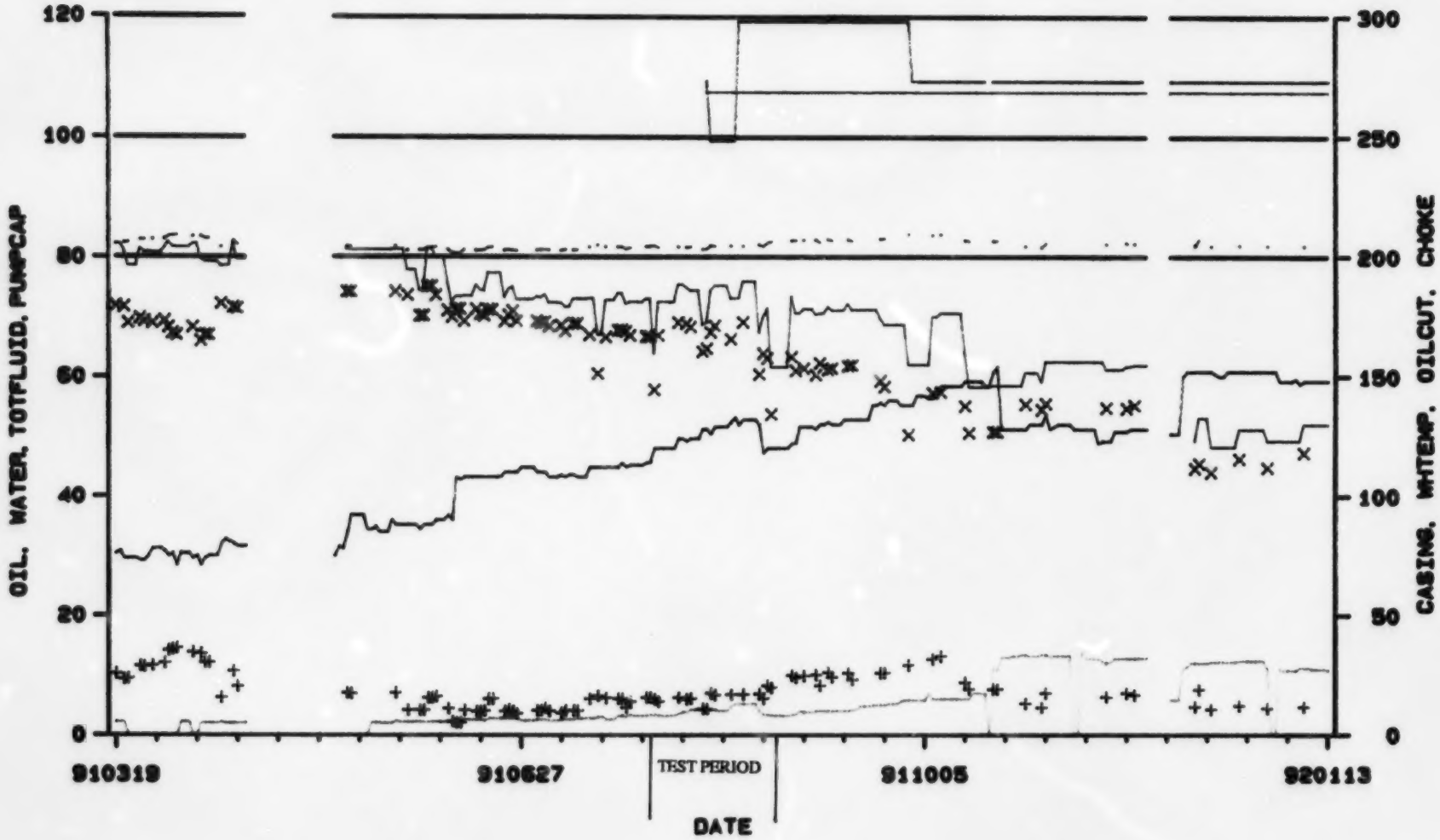


FIGURE 12

K15 PRODUCTION PLOT

OIL TEST WATER TEST PUMPCAP CASING/20 TOTFLUID WHTEMP
200+50*OILCUT 250+50*CHOKE
COMMON_NAME=OOK-15

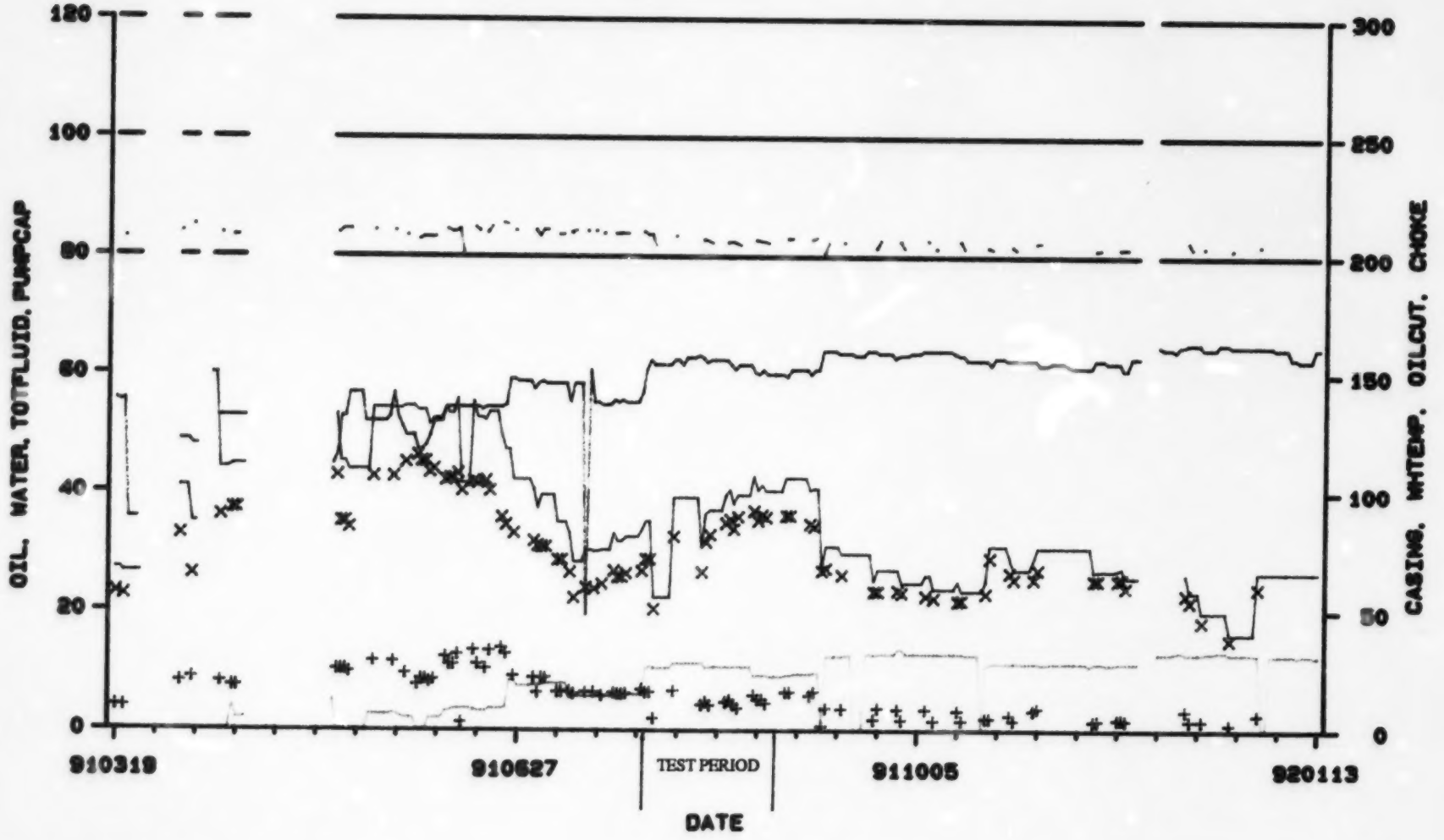
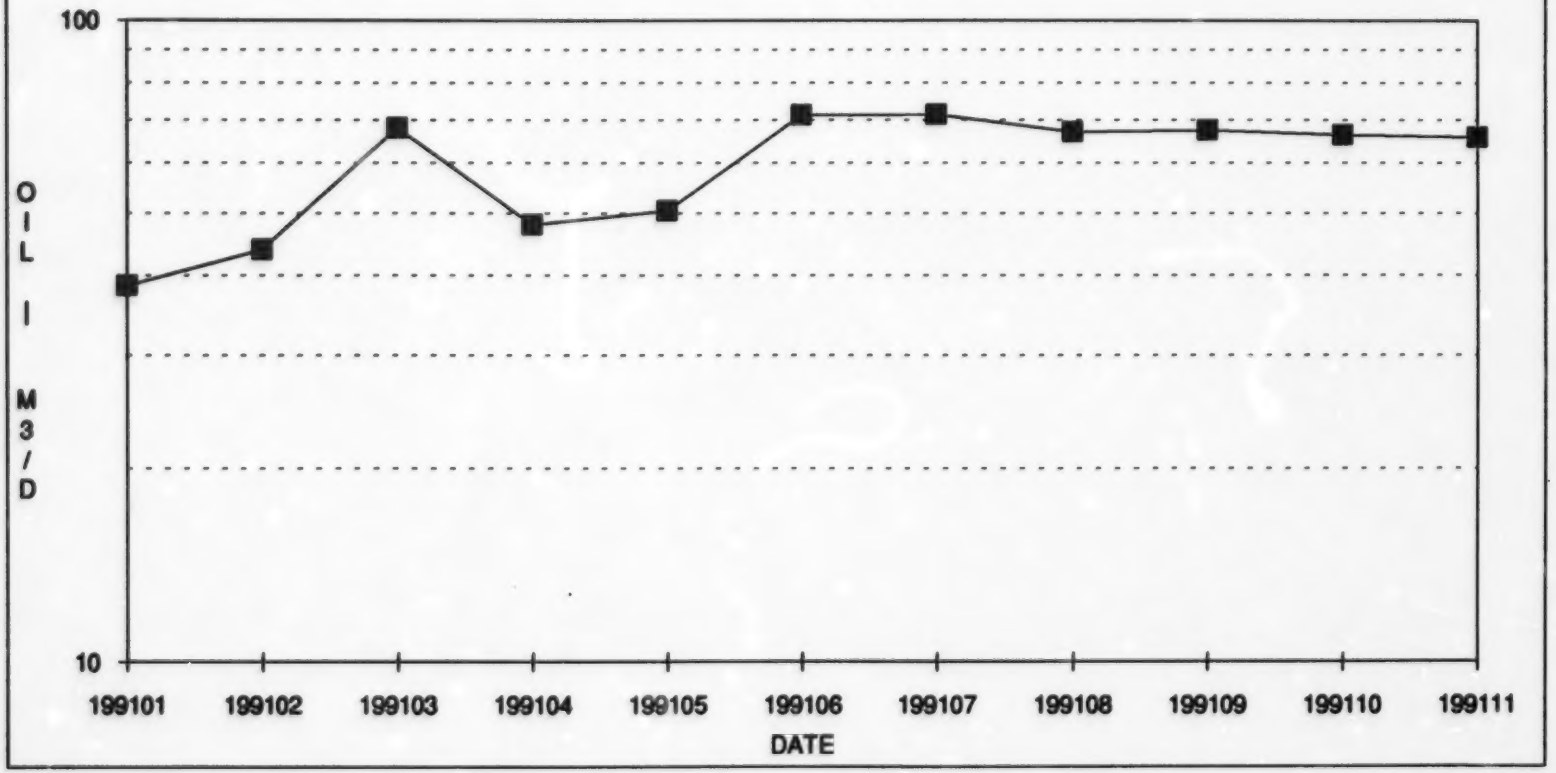


Figure 13
K PAD 1991 OIL PRODUCTION HISTORY



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